THE CONCENTRATION OF CERTAIN NITROGEN COMPOUNDS IN CORN THROUGHOUT THE MATURATION PERIOD

BY

RUSSELL EARL HAY, JR.

A.B., Miami University, 1940
M.S., University of Nebraska, 1942

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN AGRONOMY
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Introduction

This study is a part of an investigation of corn protein being carried on at the Illinois Agricultural Experiment Station. Its purpose is twofold: first, to determine whether the nitrogen stored in the vegetative parts at pollination is adequate to supply the maturing grain, and if not, the contribution of soil nitrogen to the over-all nitrogen supply after pollination. The other purpose of the study is to determine to what extent certain nitrogen compounds in the stalks and leaves at pollination contribute to the proteins of the maturing grain. The plan was to make this study on corn grown under field conditions on a naturally fertile soil in which there was little or no deficiency in the nitrogen supplying capacity for the crop grown.

Since the advent of hybrid corn, the commercial corn feeders have noted what they believe is an over all drop in the protein content of corn. This is probably due to a decrease in the nitrogen supplying power of the soil and to increased planting rates. It has been shown by Earley that on fields with average nitrogen levels the protein content of corn decreases with increased rates of planting. His work has also shown that increased yields and a protein increase of approximately 1½% can be realized with adequate applications of nitrogen fertilizer. This work indicates that both protein and yield may be kept at a reasonably high level if the proper cropping system is followed and a satisfactory nitrogen balance is maintained in the soil.

Methods

To accomplish the aims set forth in the introduction, two

corn hybrids, US 13 and Funk's G 80 were planted on a rich dark colored soil, probably Drummer clay loam. No fertilizer was applied for this crop, although a good crop of second year mammoth clover was plowed under. Random samples were taken throughout the maturation period. At each sampling plants deviating too much from the current stage of development of the field were discarded. The remaining plants numbering 14 to 26 per sample were dissected into their constituent parts. These parts were upper stalk, lower stalk, upper leaves, lower leaves, shank, husk and grain. The composite sample of each part was weighed immediately, chopped in a Hobart food chopper and representative aliquots were taken for oven drying, lyophiling and moisture determination.

A study was made of the chemical composition of the various parts of the plant from pollination to maturity in order to determine the sources of nitrogen for the corn grain. Both hybrids were used in the total nitrogen study while the investigation of the water soluble nitrogen was confined to upper and lower leaves, upper and lower stalk and grain of US 13. The total, water insoluble, water soluble, protein, non-protein, nitrate, ammonia, glutamine amide, asparagine amide, free a-amino and undetermined nitrogen were measured in the water extract of the various plant parts.

Summary And Conclusions

A summary of the results of the above studies and conclusions follow.

1. The grain produced by an average plant of US 13 contained 2.57 g. of nitrogen at maturity. This amount of nitrogen was equal to 67% of the nitrogen found in the whole plant, including the grain, at maturity. The grain thus contained twice as much nitrogen at maturity as did the vegetative parts. The percentage of total nitrogen was 1.59 in the mature grain.

The grain of G 80 contained 2.83 g. of nitrogen per plant at maturity. The nitrogen of the mature grain made up about 69% of the nitrogen found in the whole plant, including the grain, or about 2.2 times as much nitrogen as the rest of the plant, and the mature grain contained 1.54% total nitrogen.

2. Just after pollination there was enough nitrogen in the corn plant to completely supply the maturing grain if it could have been translocated. If the maximum accumulation of nitrogen in the vegetative parts is set down and the lowest subsequent value is subtracted from it, the remainder may be considered the contribution of nitrogen by the plant parts to the grain. The rest of the nitrogen must have come from the soil during the maturation period. By using this method of reasoning, it is seen that approximately 45% of the nitrogen in the mature grain of US 13 was contributed by the soil after pollination. A similar percentage of nitrogen, 47, was found to be contributed by soil after pollination to the maturing grain of G 80. These percentages indicate that approximately 54% of the nitrogen in the mature grain has been taken up by the time of pollination and the remainder is absorbed from the soil afterwards.

It is virtually impossible to separate the root system of a corn plant from the soil in which it grows. For this reason it is impossible to obtain more than a gross approximation of the weight of such a root system. The root system does however constitute a substantial portion of the weight of the entire corn plant. Considering this fact it must be admitted that a part — and no doubt a considerable part — of the grain nitrogen attributed to soil origin after pollination actually was furnished at the expense of root nitrogen.

3. The comparative contributions of nitrogen by the vegetative parts to the maturing grain are outlined. The leaves of both hybrids contribute the most nitrogen to the maturing grain as shown by losses from them. If the percentage which is lost from the highest accumulation of

nitrogen in the part is considered, the husks of both hybrids appear to be the greatest contributors to the grain proteins. However, on a quantitative basis, the husks contribute only 20% as much nitrogen as do the leaves.

4. A comparison of the contributions of nitrogen by the nitrogen fractions, presumably to the maturing grain, is shown. The nitrogen supplied by the leaves is a more important index to the source of nitrogen for the grain protein than is found in the stalks. The stalk is the pathway from the leaves to the grain, and the nitrogen found in the stalk at a particular sampling may be, to a considerable extent, in transit. This is indicated by the fact that from pollination through the dough stage, the amount of water-soluble nitrogen in the stalks is from 2½ to 3 times as great as in the leaves. Another comparison indicates that the insoluble fraction of the leaves, which is considered in this work to be largely protein, loses more nitrogen than the water soluble portion. The loss of water insoluble nitrogen from the leaves is greater in both amount and percentage of the maximum accumulation subsequently lost than is the loss from the water soluble portion. This might be construed to indicate that there is a build-up of leaf proteins and that these proteins are later hydrolized and furnish a considerable amount of nitrogen to the proteins of the maturing grain. The upper leaves seem to furnish more nitrogen to the grain proteins than do the lower ones.

5. The study of the water soluble nitrogen compounds of US 13 was made in an attempt to learn in what forms the nitrogen was furnished from the hydrolized proteins and from the incoming nitrogen to the grain for protein synthesis. A comparison is made of the losses by the various forms of nitrogen measured in the water extract. The loss is the difference between the maximum accumulation and the lowest subsequent value for the same form of nitrogen. In the upper and lower leaves the nitrogen which was not determined in the water extract showed the largest losses. The fact that

comparatively large quantities of nitrate nitrogen are found in the leaves may be construed to mean that the seat of nitrate reduction in corn is in the leaves or at least the major portion of it. Nitrate nitrogen, the potential source for organic nitrogen, showed the next largest losses. In both the leaves and the stalk the contributions of the other nitrogen forms studied were in the following order: alpha-amino nitrogen showed the greatest losses followed by the amide nitrogen of asparagine, amide nitrogen of glutamine and the ammonia nitrogen. These losses are considered contributions to the proteins of the maturing grain.

6. In summing up it may be said that somewhat over 50% of the nitrogen in the maturing grain of corn is obtained substantially from the leaves after pollination. The evidence points strongly to the conclusion that of the various forms of nitrogen in the leaves, protein and the more complex protein derivatives contribute the major portion of nitrogen to the grain. Smaller but nevertheless important donations of nitrogen to the developing grain are made by the simpler compounds including the nitrate, ammonia, amide and a-amino forms. No final conclusions can be drawn from this investigation as to the chemical route followed by nitrate nitrogen taken from the soil after pollination and previous to its deposition in the grain. It is believed that the evidence favors the view that it is converted into protein or nearly protein and then hydrolyzed to a movable form for translocation to the grain.

VITA

The writer was born January 5, 1918 in Dayton, Ohio, attended the public schools of Dayton and was graduated from Fairview High School in 1936. He matriculated in Miami University where he was appointed Assistant in Botany in 1938. The Bachelor of Arts degree was conferred in June 1940. In the Fall he enrolled in the Graduate College of the University of Nebraska and was appointed Graduate Assistant in Botany January 1941. The degree of Master of Science was awarded January 1942.

He enlisted in the Armed Forces October, 1941, was later commissioned and returned to inactive duty February, 1946.

In March of 1946 he entered the Graduate College of the University of Illinois. The same month he was appointed Special Research Assistant in Agronomy.

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